Music Technology A-level

Topics 1-12

Name:

Contents

Topic		Page
1	**Introduction to Sound** What is sound? What is the impact of frequency and amplitude? How does this relate to phase, harmonics and wave cycles?	3
2	**Microphones** What are the different types of microphones? What properties are important when choosing a mic, and how do they pick up sound?	6
3	**Synthesisers** What do the different parts of synthesiser do? What types of synthesiser exist and what are they used for? What are envelopes and LFOs?	9
4	**Dynamic Range Processing** How do compressors and noise gates control the volume of sounds? What are limiters, and what creative things can we do with dynamics?	12
5	**EQ and Filtering** What is an EQ? How is EQ applied and how do we use filters correctively and for creative effects? What do filter graphs look like?	15
6	**Reverb** How was reverb created? What is it? How do we generate reverb now, and what parameters can we change?	21
7	**Samplers** What is sampling and what is a sampler? How can they be used? How can samples be manipulated and what must we bear in mind?	26
8	**Delay Effects** What does a delay do? How was delay created historically? What parameters might we see on a delay? What different types are they?	29
9	**Modulation Effects** What is modulation and how are LFOs used to create it? What effects are created with modulation and what do they sound like?	32
10	**Distortion Effects** What are the different types of distortion? How is it created? What functions / parameters might you see on a distortion effect?	36
11	**Creative Effects** What other effects can be used creatively in Music Technology? What do they sound like? How are the parameters changed?	39
12	**MIDI** What is MIDI? What impact did it have on Music Technology? What are MIDI controllers and how can we use them to create musical work?	41

1 Introduction to Sound

Learning Objectives:

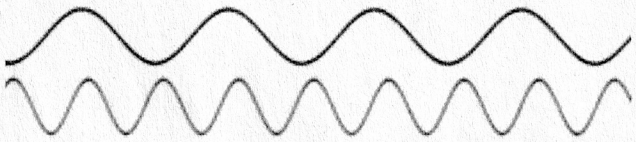
- Identify how **sound travels in air**
- Discuss waves in terms of **amplitude and frequency**
- Consider the effects of **phase** and the **impact of this on recording**

What is Sound?

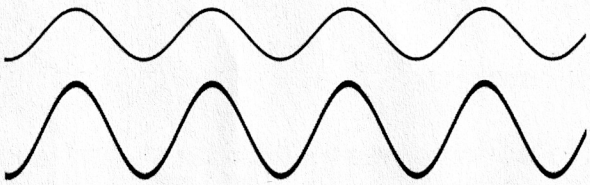
- Sound moves in air through a **vibration causing a disturbance in air particles**.
- This causes them to **move towards** each other and **eventually transfer the vibration to our eardrum**.
- A sound wave tells us **lots of information** about the sound itself.

Frequency and Amplitude

- We can think of a sound wave in two main ways; its **amplitude** and its **frequency.**



The bottom wave has a higher frequency



The bottom wave has a louder amplitude

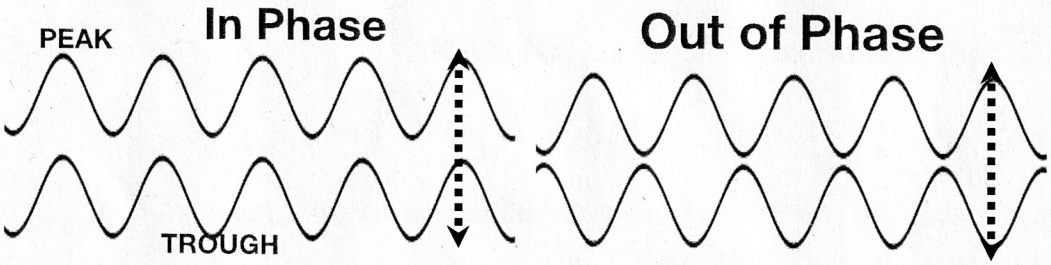
- An increase in amplitude gives a louder volume. An increase in frequency gives a higher pitch.
- Dynamic range processors change the **volume / amplitude** of the sound.
- **Filters** and **equalisers** change the volume of (add or remove) **frequencies** in a sound.

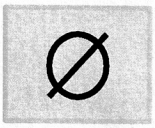
Wave Cycles

- A **wave cycle** is a 'complete wave' that moves from 0, through its maximum and minimum, then back to zero again.
- **Hertz** is a measurement of **frequency.**
- If a wave completed one cycle in one second, we would say that it had a frequency of **1Hz.**
- Humans can hear between **20Hz and 20,000Hz**. We can simplify this by remembering **20Hz to 20kHz.**
- Higher-frequency hearing tends to **deteriorate as we get older.**
- **Amplitude** is measured in **decibels.** This is written as **dB**.

Phase

- If sound waves are in phase, then their peaks & troughs line up
- If sound waves are **out of phase** then the peaks & troughs do not line up and cause destructive interference, which sometimes can **completely cancel out** the sound of the wave.
- Phase **must be considered** when recording with **two close microphones** or from **either side of a drum**.
- Many mixers and DAWs have **phase invert** buttons. **These swap the phase of the signal** to solve this problem.

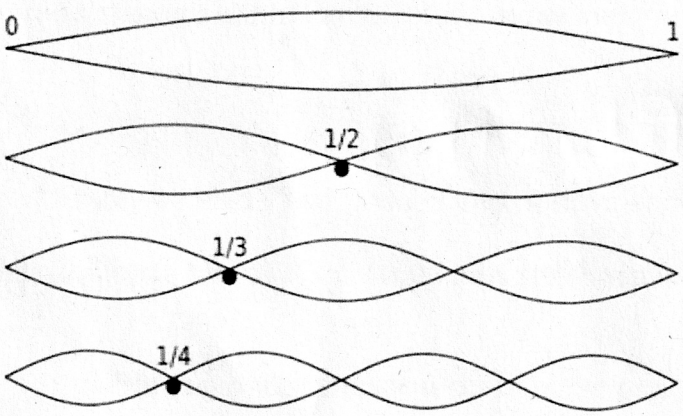




Phase Invert

Harmonics

- **Harmonics** are mathematically and musically related waveforms.
- They occur **naturally** when a note is played as an **oscillation on a string or tube**. When this occurs, you hear **one main note**, but also a number of **other, quieter frequencies.**
- Rather than hearing these as notes, they often form **part of the sound's timbre.**
- It is possible to isolate **higher harmonics** on **stringed** and **wind** instruments. This changes the **timbre** of the note, often sounding 'thinner' or 'cleaner'.
- Harmonic waveforms fit **exactly onto themselves**.



Fundamental and Harmonic Waveforms

1 Introduction to Sound — Key Terms

Define the following key terms:

Terminology	Definition
Volume	A subjective perception of how loud a sound is.
Amplitude	The height of a waveform measured from its mean or zero position to its maximum displacement
Frequency	The pitch of a sound
Wavelength	The distance between two successive peaks or two successive troughs in a wave
Hertz	measurement of frequency: Hz means oscillations per second
Cycle	A 'complete wave' that moves from 0, through its maximum and minimum, then back to 0 again.
Oscillation	Regular variation in magnitude or position about a central point.
Phase	Ø phase invert symbol The position of a wave at a point in time on a waveform cycle
Constructive Interference	When sound waves are in phase then the peaks and troughs line up, increase the amplitude
Destructive Interference	When sound waves are out of phase then the peaks and troughs do not line up, decreasing the amplitude.
Harmonics	mathematically and musically related waveforms.
Decibel	written as dB because the unit is bels and deci is used at the front.
XLR	A connector commonly found on microphones and other balanced signals.

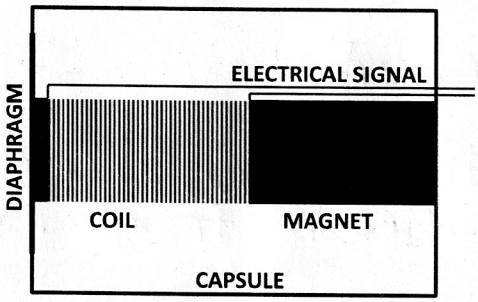
2 Microphones

Learning Objectives:

- Identify the differences between **dynamic and condenser** microphones in terms of sound generation, benefits and drawbacks
- Understand and use the terms **transducer** and **electromagnetic induction**

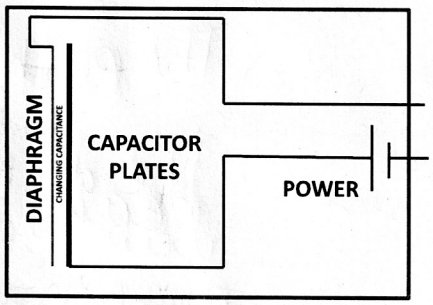
- A microphone is a **transducer that converts** between **sound and electrical energy**.
- There are two important types of microphone; **dynamic** and **condenser**.

Dynamic Microphones



- Dynamic microphones use **electromagnetic induction** to capture a sound signal.
- The sound causes the **vibration of the diaphragm**, which causes the magnet to move through the coil. This **induces an electrical current** in the coil that is proportional to the disturbance of the diaphragm.
- Dynamic microphones are often used for sources with a high SPL (**sound pressure level**, or **volume**). They are robust and often **relatively inexpensive**, and don't require phantom power.
- However, their **high frequency response** is often worse than condensers & they have a **low output volume**.

Condenser Microphones



- Condenser microphones use a capacitor to capture sound. The sound causes the **vibration of the diaphragm**, which is one plate of a capacitor.
- As the capacitor plates are **powered,** moving the diaphragm causes a **change in capacitance** & thus a **current flows.**
- Condenser microphones are often used **for studio work** as they have **a wide and flat frequency response** and capture high frequencies well. They are **very sensitive**.
- However, because the capacitor needs powering, condenser microphones require **phantom power** or a battery, and can be quite **expensive** and **fragile**.

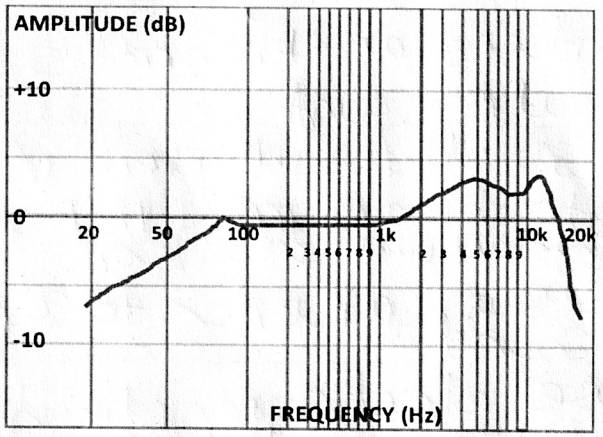
Other Microphones

- **Ribbon** microphones are expensive, delicate and used for high quality, accurate recordings
- **PZM** microphones are pressure zone microphones, and used to capture reflections
- **Electret** microphones are cheaper condensers that have a permanently charged plate
- **Contact** microphone are often used as pickups on acoustic instruments

Frequency and Transient Response

- A microphone's **frequency response** tell us the frequencies it picks up in relation to the human hearing range. It is common to see a **graph** of a microphone's frequency response.

- The **flatter the graph**, the more **'true'** the sound is. If a graph has any particular peaks, this means that those frequencies are captured louder than they are in 'real-life'. This is **colouration.**

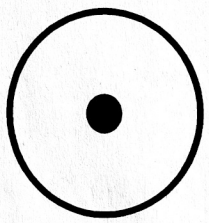


Graph of Frequency Response

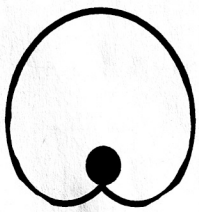
- A microphone's **transient response** is how quickly the diaphragm can move when disturbed by a vibration. **Large diaphragm** condenser microphones tend to have a fast transient response.

Polar Patterns

- A microphone's **polar pattern** is how it picks up sound from around the capsule. There are four main polar patterns:



Omnidirectional



Cardioid

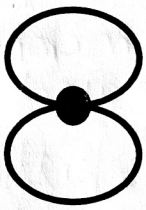
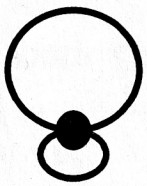


Figure-of-Eight



Hypercardioid

Recording with Microphones

- The **proximity effect** is when low frequencies are emphasised when you get closer to the microphone. This can be fixed by **moving further back** or by **using EQ** later on. Sometimes this effect is used to **give a 'warmer' sound.**

- **Plosive** sounds cause a big disturbance in a microphone's diagram causing a 'pop' sound. Sounds like 'p' and 'd' are particularly bad for this. A **pop shield** can be used to avoid such issues.

- **Sibilance** is 's'-like sounds which jump through the mix. Some engineers tape a pencil to the microphone to avoid this, or a **deesser** can be used in production.

2 Microphones — Key Terms

Define the following key terms:

Terminology	Definition
Transducer	converts between sound and electrical activity
Coil	Induces an electrical signal which creates sound
Diaphragm	A small flexible piece of material in a microphone that responds to physical vibrations of sound
Condenser	Uses a caracitor to capture sound
Dynamic	Use electromagnetic induction to capture a sound signal.
Ribbon	expensive delicate microphones used for high quality recordings
PZM	Prezzue zone microphones
Electret	Cheaper condensers that have a permanently charged plate
Polar Pattern	how microphones pick up sound from arand the capsule
Electromagnetic Induction	the vibration of the diaphragm which causes the magnet to move through the coil.
Proximity Effect	low frequencies are emphasised when you move closer to the microphone.
Frequency Response	how microphones pick up different frequencies
Plosive	sounds like 'p' and 'd' which cause a pop sand
Sibilant	's' like sounds which jump through the mix

3 Synthesisers

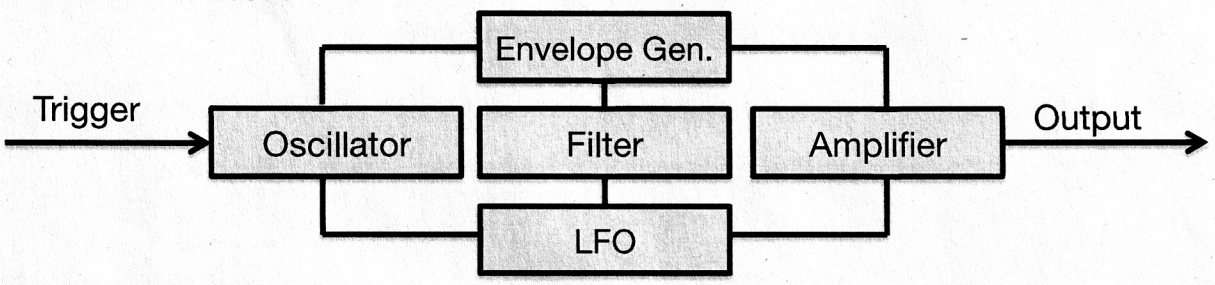
Learning Objectives:

- Identify **synthesiser modules** and their **functions**
- Discuss **types of synthesis**
- Consider the **functions of other parts** on a **simple analogue synthesiser**

What is a Synthesiser?

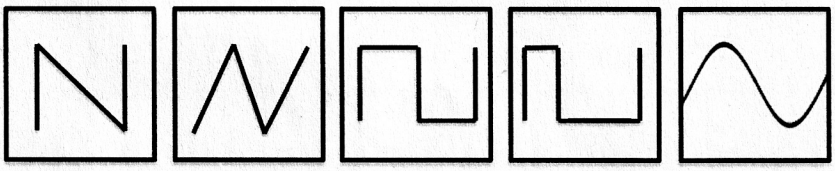
- A synthesiser is an **electronic sound generator** capable of **creating & manipulating** synthetic sounds.
- **Analogue** synthesis uses an **electrical voltage** to generate a signal which is then shaped.
- **Digital** synthesis can use **computer technology** to model other synthesisers & generate sounds. **FM synthesis** (frequency modulation) is a type of **digital synthesis**.
- **Subtractive** synthesisers start with a **harmonically rich waveform** & use filters to remove frequencies. **Additive** synthesisers **layer up simple waveforms** (e.g. sine waves) to produce a more complex wave.
- A synthesiser's **polyphony** tells us how many notes it can play simultaneously. A monophonic synthesiser can only play one note at once.
- **Glide** or **portamento** allows a synth (often monophonic) to slide between two notes.

Synthesiser Modules



- The **oscillator** generates an **initial sound** & **allows you to select a waveform.**

Synthesiser Waveforms

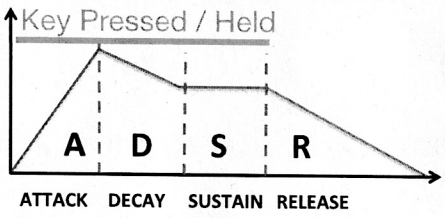


- The **filter removes frequencies** to shape the sound. Synths often incorporate a **low pass filter**, which removes all of the frequencies **above the cut off frequency**.
- The **amplifier** controls the **sound's volume.**

- The **envelope generator** changes the **attack, decay, sustain** & **release** of the sound.
    - An envelope can be applied to the **oscillator**, **filter** or/and **amplifier** in lots of synthesisers

ATTACK
Time taken for sound to increase from 0 to decay phase.

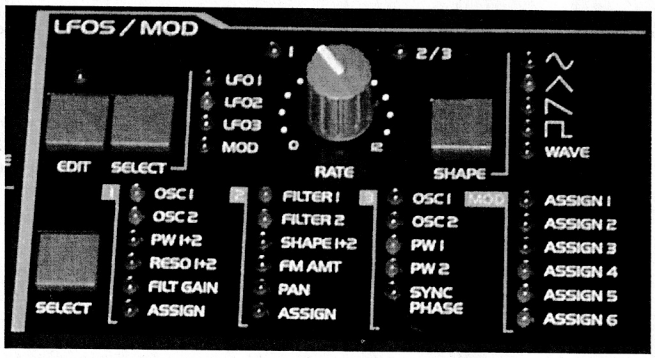
DECAY
Time taken for sound to fall to sustain level



SUSTAIN
Level at which the note holds whilst key remains pressed

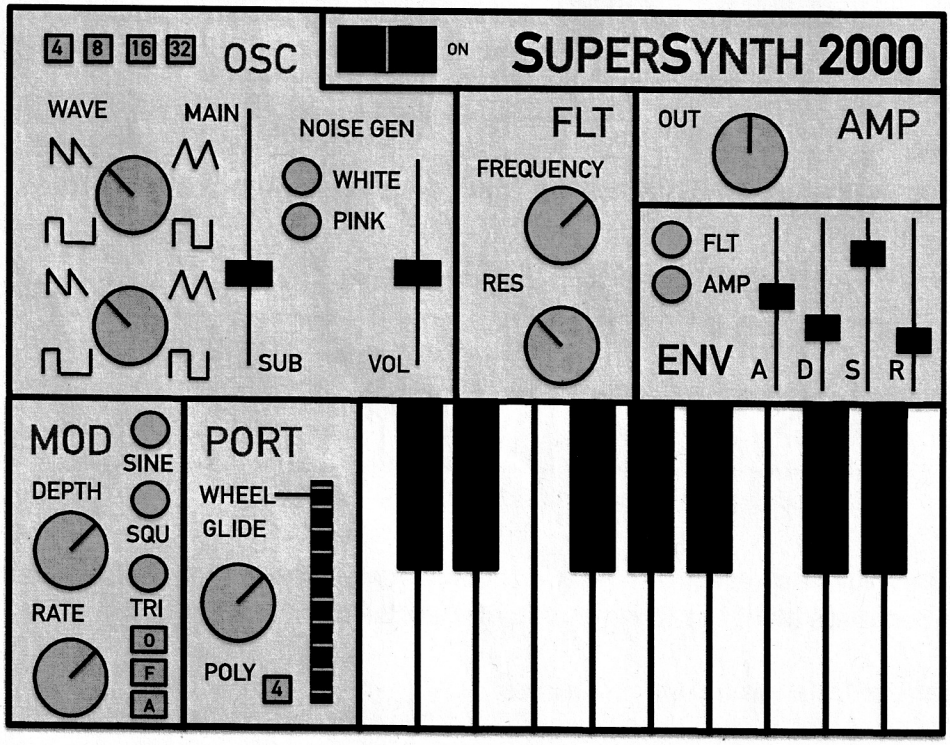
RELEASE
Time taken once key released for note to fall to 0

- The **LFO modulates a parameter** of the sound over time and according to another waveform (e.g. pitch=vibrato)



LFO / Modulation Section of a Synthesiser

- **Label** the synth diagram below with **what each function does** and **its impact on the sound.**



3 Synthesisers — Key Terms

Define the following key terms:

Terminology	Definition
VCO	Voltage Controlled Oscillator, generates waveforms used for sound generation and modulation.
VCF	Voltage Controlled Filter, removes frequencies to shape the sound.
VCA	Voltage Controlled Amplifier, controlled often by an envelope.
Resonance	Emphasises portions of the signal above (HPF) or below (LPF) the defined cutoff frequency.
Cut off frequency	Determines the point where lower frequencies are suppressed and higher frequencies above this can pass
Envelope	Changes the attack, decay, sustain and release of the sound.
LFO	Low Frequency Oscillation, oscillator that oscillates between 0 to 20 times a second (0-20Hz)
Analogue/Digital	Analogue uses electrical voltage to generate a signal which is shaped while Digital uses computer technology to model other synthesizers
FM Synthesis	A type of digital synthesis with a carrier wave and a modulator wave.
Trigger	A short signal that is sent when a key is pressed
Polyphonic	tells us how many notes it can play simultaneously.
Monophonic	Can only play one note at once.
Legato	Smooth playing with no gaps in between.
Glide	Allows a synth to slide between two notes.
Pitch Bend	A control on synthesisers to bend the pitch up and down
Modulation	Literally means changing but used to include effects with some movement to them.

4 Dynamic Range Processing

Learning Objectives:

- Identify and discuss the function of **dynamic range processors**
- Discuss the **parameters** commonly found on dynamic range processors
- Describe and **aurally identify** some of the ways dynamic range processing is **used creatively**

- The difference between the loudest and quietest parts of a track, song or part is known as the **dynamic range**. It is very important in Music Technology to be able to **control the dynamic range**. There are two key processes to know about, and a couple of extra ones that are useful to us:

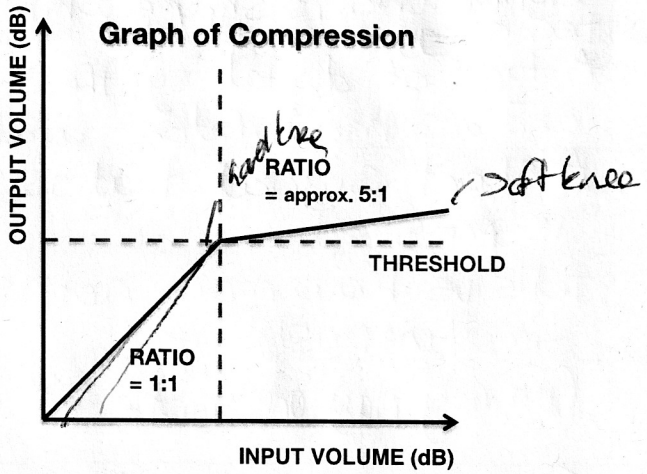
Compression

- A compressor **reduces the dynamic range.** It is applied by **'pulling down'** the loud parts of a track and then **raising the overall volume**, which makes it seem **consistently louder** and the average volume will be higher.

- The volume above which a compressor begins to compress is called the **threshold**. The **ratio** is the input volume : output volume and how much the compressor will reduce the signal by.

- **Attack and release** control how quickly the compressor will reduce the volume and allow it to return to normal once it falls below the threshold again.

- A hard knee compressor (like below) applies the compression specified by the ratio **instantly at the threshold.** A soft knee compressor **gradually increases** the ratio slightly before and after the threshold; this looks more like a **curve.**



- **Multiband compression** allows **different parts of the frequency spectrum** to be compressed in different ways (avoids pumping).

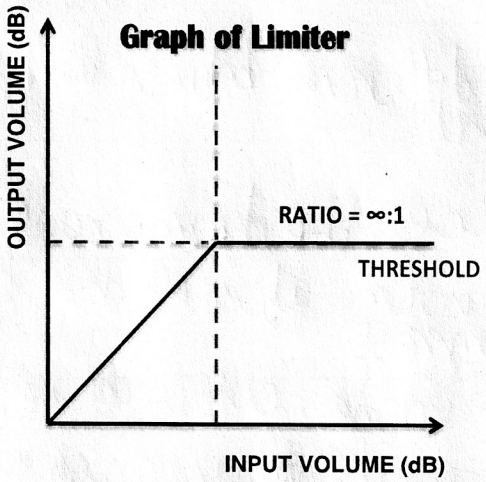
- **Sidechain** compression is where a compressor is triggered by one track, but the actual compression is applied to another (e.g. causing a pad to 'duck' with the kick drum).

Sean Kingston – Fire Burning
Galantis – Runaway (U&I)

- **Deessers** are a form of multiband compression that only compresses mid-high frequencies, reducing the volume of 's' sounds that may be too prevalent in a recording.

Limiting

- **Limiters** will not let the volume of the sound go past 1dB. They can be used to protect equipment & are essentially extreme compressors.

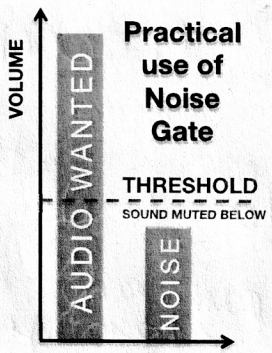


Noise Gating

- A noise gate **expands the dynamic range.**
- It is applied by removing all audio that **falls below a certain level**, meaning that background noise can be removed as long as nothing else is playing at the same time.
- The volume below which a noise gate silences audio is known as the **threshold.**
- Like compressors, **gates can also be sidechained,** and this is often used in dance music.

MaRLo - Barracuda

- **Attack, hold** and **release** control how quickly the noise gate opens, how long it will stay open for once a sound passes the threshold and how long it takes to close once a sound's volume falls below the threshold.
- **Lookahead** preempts a sound passing the threshold level and ensures the sound's attack is not lost.
- An **expander** expands the dynamic range by reducing the volume of sounds below threshold (does not completely silence).



4 Dynamic Range Processing — Key Terms

Define the following key terms:

Terminology	Definition
Dynamic Range	the difference between the loudest and quietest sounds
Compression	Reduces the dynamic range
Threshold	The volume above which a compressor begins to compress
Ratio	input volume : output volume and shows how much the compresser will reduce the signal by
Make Up Gain	Bringing the volume up as the compression reduced the amplitude
Attack Time	Control how quickly the compressor will start working
Release time	controls how quickly the compresser will stops working after dropping below the threshold
Peak	~~Applies the compression to the~~ A setting on the compressor that calculates the volume
RMS	A setting on the compressor that calculates hardknee the amplitude
Knee	Applies compression as soon as it is used instantly softknee- gradually increases the ratio
Limiter	will not let volume of the sounds go past the threshold
Overcompression	If too much compression is applied to a track
Sidechain	Putting a compresser on a track but it is acting on another track
Noise Gate	Expands the dynamic range and removes all audio below a certain level.

5 EQ and Filtering

Learning Objectives:

- Identify **filter parameters**
- Discuss **types of EQ and filter**
- Consider ways in which EQ and filtering **can be used creatively in Music Technology**

- **Equalisation** is the process by which different frequency ranges are increased or decreased in volume.

- EQ units are made up of lots of **filters**. A filter can also be used by itself, and removes all frequencies beyond a **cut off**. The filter's **slope** determines how abruptly this happens.

Filter Parameters

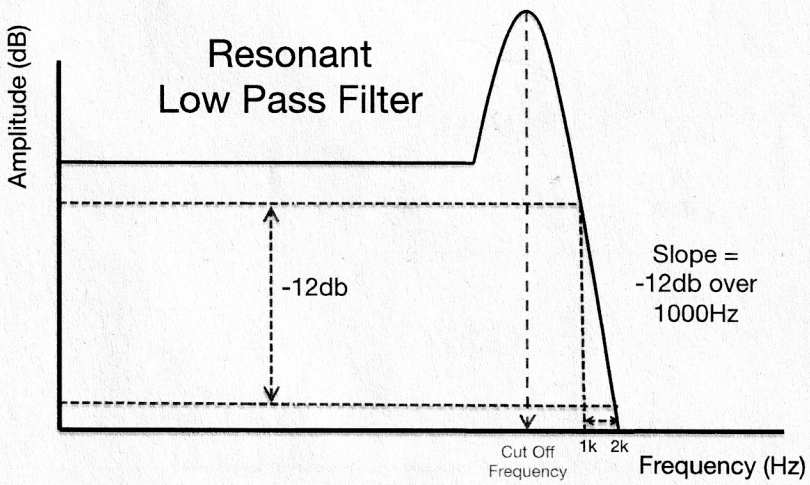
Cut Off Frequency	The cut off frequency is the point at which the filter begins to remove frequencies; it is precisely measured at the point where the amplitude has dropped by 3dB.
Centre Frequency	The centre frequency is the mid-point of a band pass filter. It is precisely measured at the point where the outer limits of the filter have reduced in volume by 3dB.
Q / Bandwidth	The width (or 'bandwidth') of a band pass filter; a high value means that the filter is very narrow.
Resonance	Characteristic narrow boost of the frequencies around the cut off, which makes the sound 'whistly' or if over-used, introduces self-oscillation.

Low Pass Filters

- **Low Pass Filters** remove frequencies that are **above** a cut off frequency (i.e. allows the lows to pass)

- When the filter has a curve, the cut off frequency is often measured at the point when 3dB of amplitude reduction has occurred.

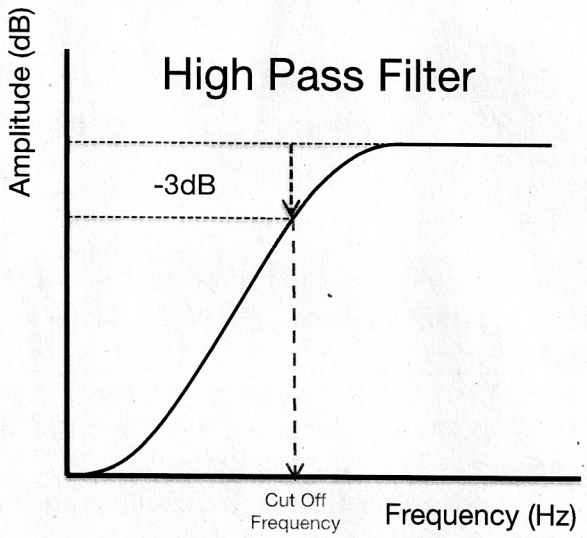
- The cut off frequency in the diagram below is approximately **1000Hz.**



Low Pass Filter Graph

High Pass Filters

- **High Pass Filters** remove frequencies that are **below** a cut off frequency (i.e. allows the highs to pass)
- **They are often used as rumble filters** during recording to remove low frequency sounds that may have accidentally have been recorded

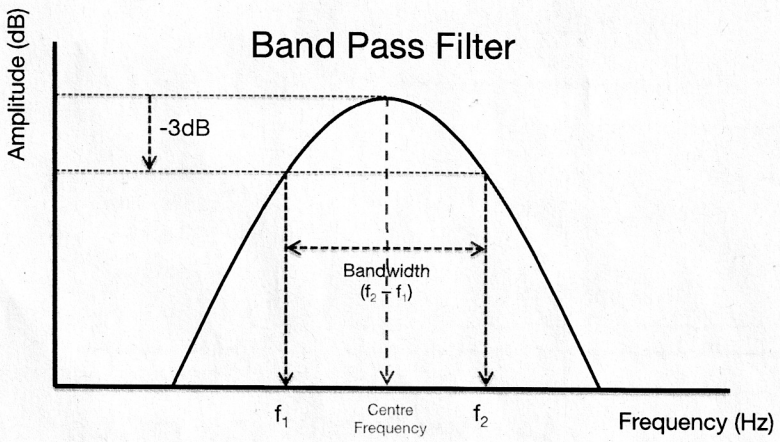


High Pass Filter Graph

Band Pass Filters

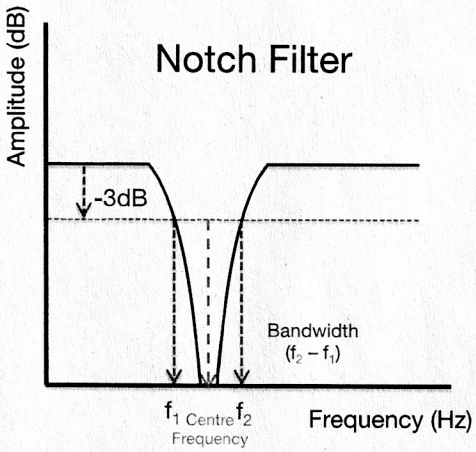
- **Band pass** filters are a bell curve around a **centre frequency**.
- The width of the curve is defined by the **Q value**
- The frequencies can be cut or boosted
- Band pass filters can be used to create a **wah wah** effect, when the centre frequency is **swept** across the frequency spectrum.

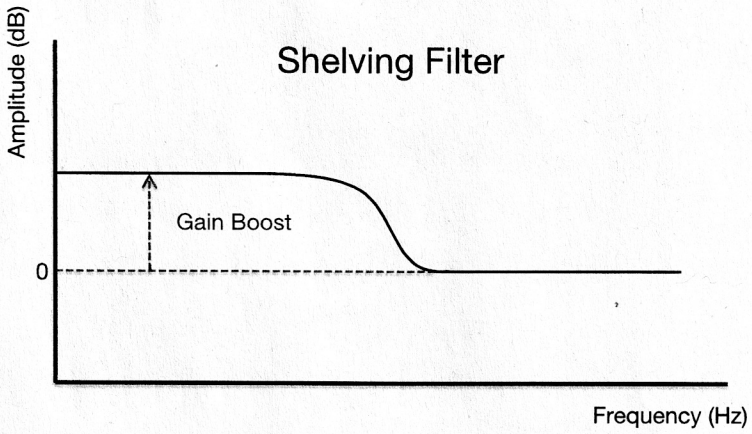
Morcheeba – Small Town



Other Types of Filter

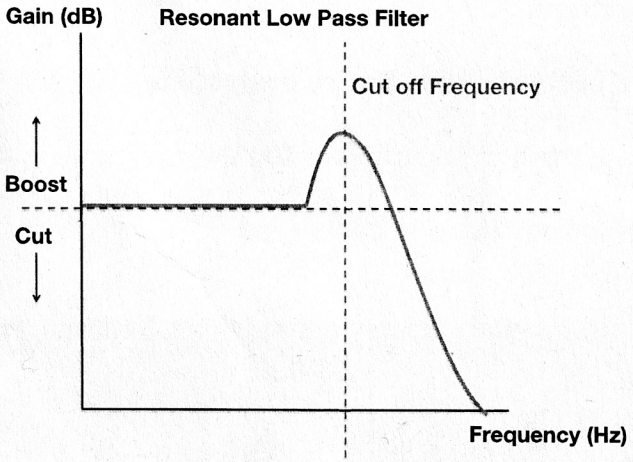
- A **notch filter** is a band pass filter with a **very high Q value** (narrow curve).
- It is used to remove a specific frequency, for example for feedback in live sound.
- A **shelving filter** boosts or cuts all of the frequencies beyond a certain point; this is applied evenly once the slope has been achieved.





Resonance

- **Resonance** is when the frequencies **around the cut off frequency** are boosted. The **Q** defines how narrow or wide the boost is.
- Resonance sounds **'whistly',** and when over-used, it can introduce **self-oscillation**, which is where the filter sounds like it is creating a musical note.



Herbie Hancock – Chameleon
Phuture – Acid Trax

Using Filters

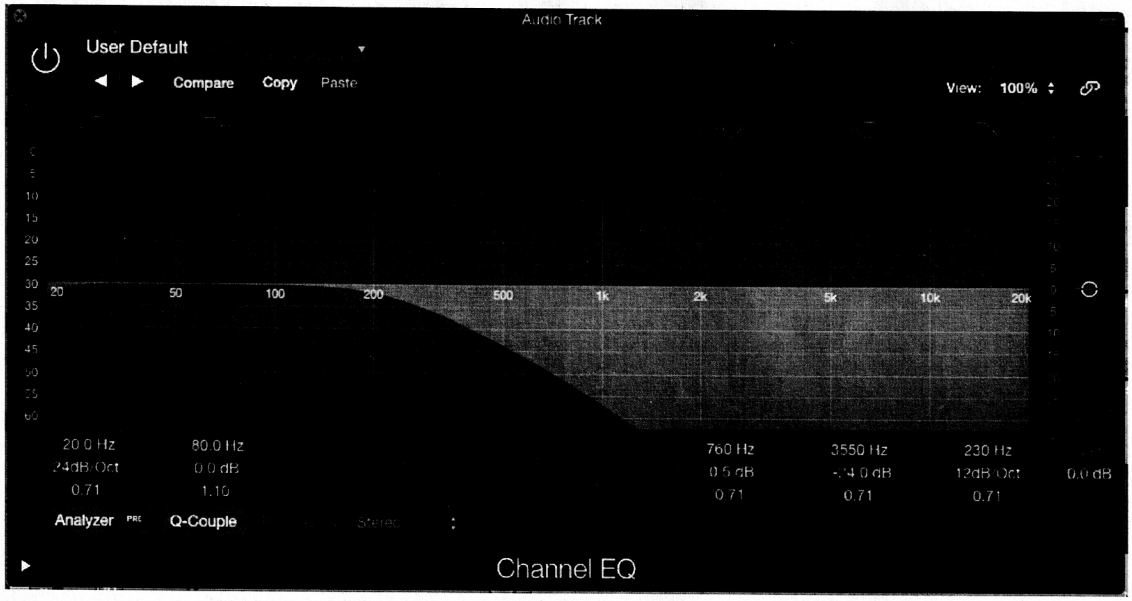
- Filters are often used in dance music to create a sense of **build or breakdown.** This is done by **automating the cut off frequency** of a **low pass** or a **high pass filter**

Shapeshifters – Lola's Theme
Kylie Minogue - Wow

Types of EQ

- **Parametric EQs** work using a number of different types of filter. Logic's **Channel EQ** is an example of a parametric EQ.

- Parametric EQs will show an **overall curve** which is created by combining all of the filters, and are often seen on DAWs, software and digital effects and processors



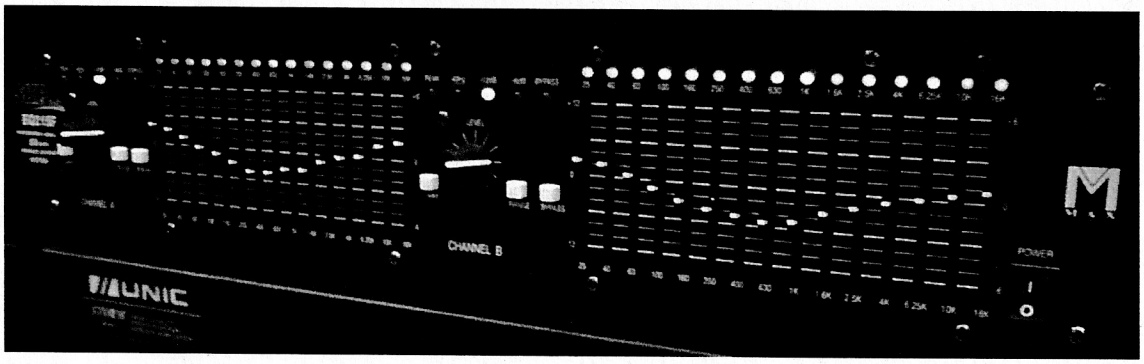
Logic Channel EQ – a Parametric EQ

- **Graphic EQs** use a bank of filters which are used to individually boost or cut specific parts of the frequency spectrum.

- The labels on the EQ sliders are the **centre frequencies** of each filter

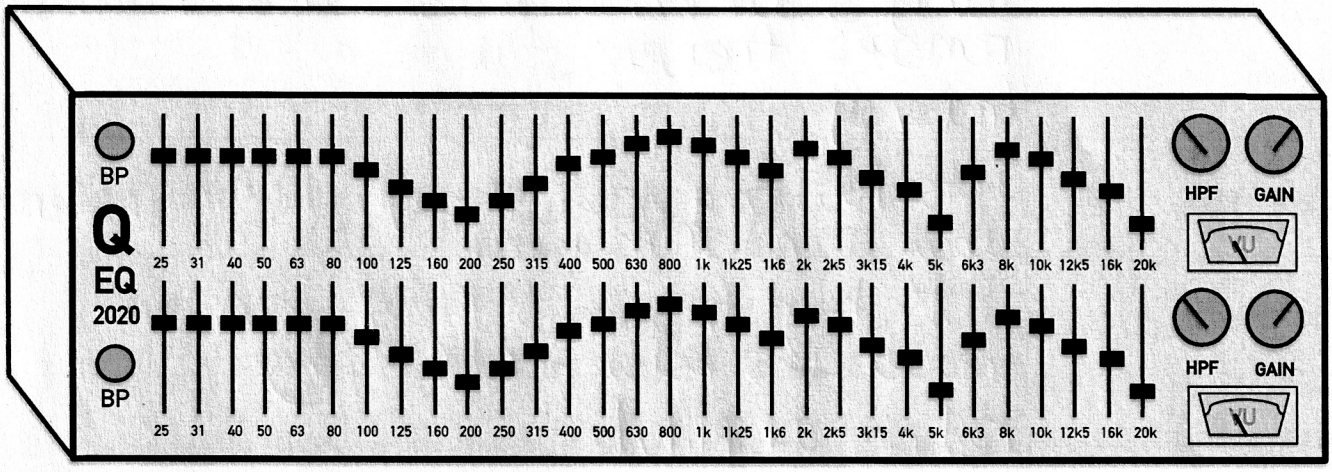
- The name comes from the fact you can see the **overall curve** when the sliders are moved

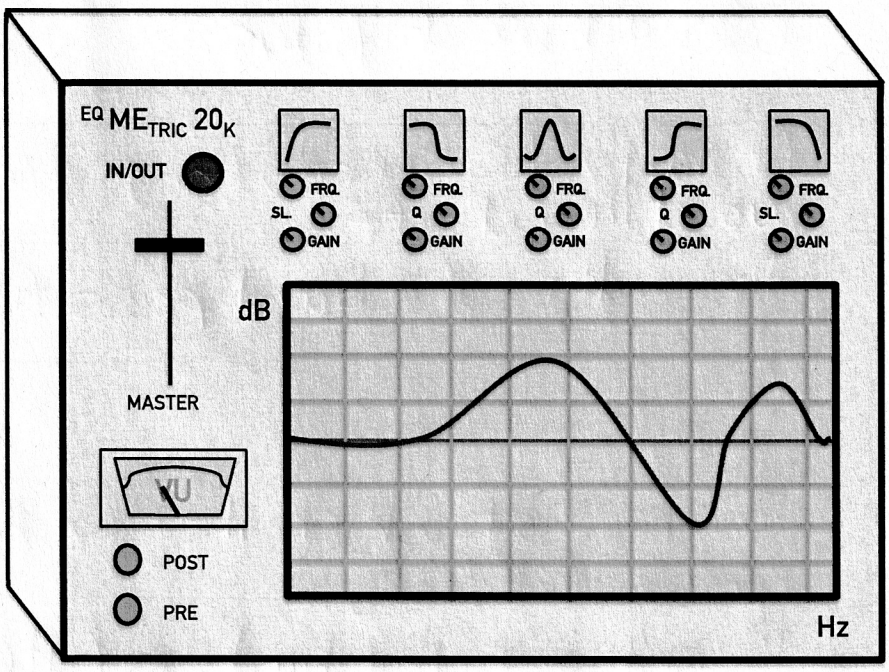
- Graphic EQs are **commonly used in live sound**



Graphic EQ

Annotate the equipment diagrams and graphs below, discussing any relevant parameters and providing information on how they function.





5 EQ and Filtering — Key Terms

Define the following key terms:

Terminology	Definition
EQ	the process by which different frequency ranges are increased or decreased in volume.
Filter	removes frequencies above a cut-off frequency
Low Pass	lets low frequencies through, remove frequencies above a cut off frequency
High Pass	lets high frequencies through, remove frequencies below a cut off frequency
Attenuation	reduces amplitude
Boost	increases amplitude
Parametric EQ	work using a number of different types of filter
Graphic EQ	uses a bank of filters.
Resonance	Characteristic narrow boost of the frequencies around the cut-off.
Q	The width of a band pass filter
Bandwidth	
Cut Off Frequency	The point at which the filter begins to remove frequencies
Centre Frequency	the mid-point of a band pass filter.
Gain	

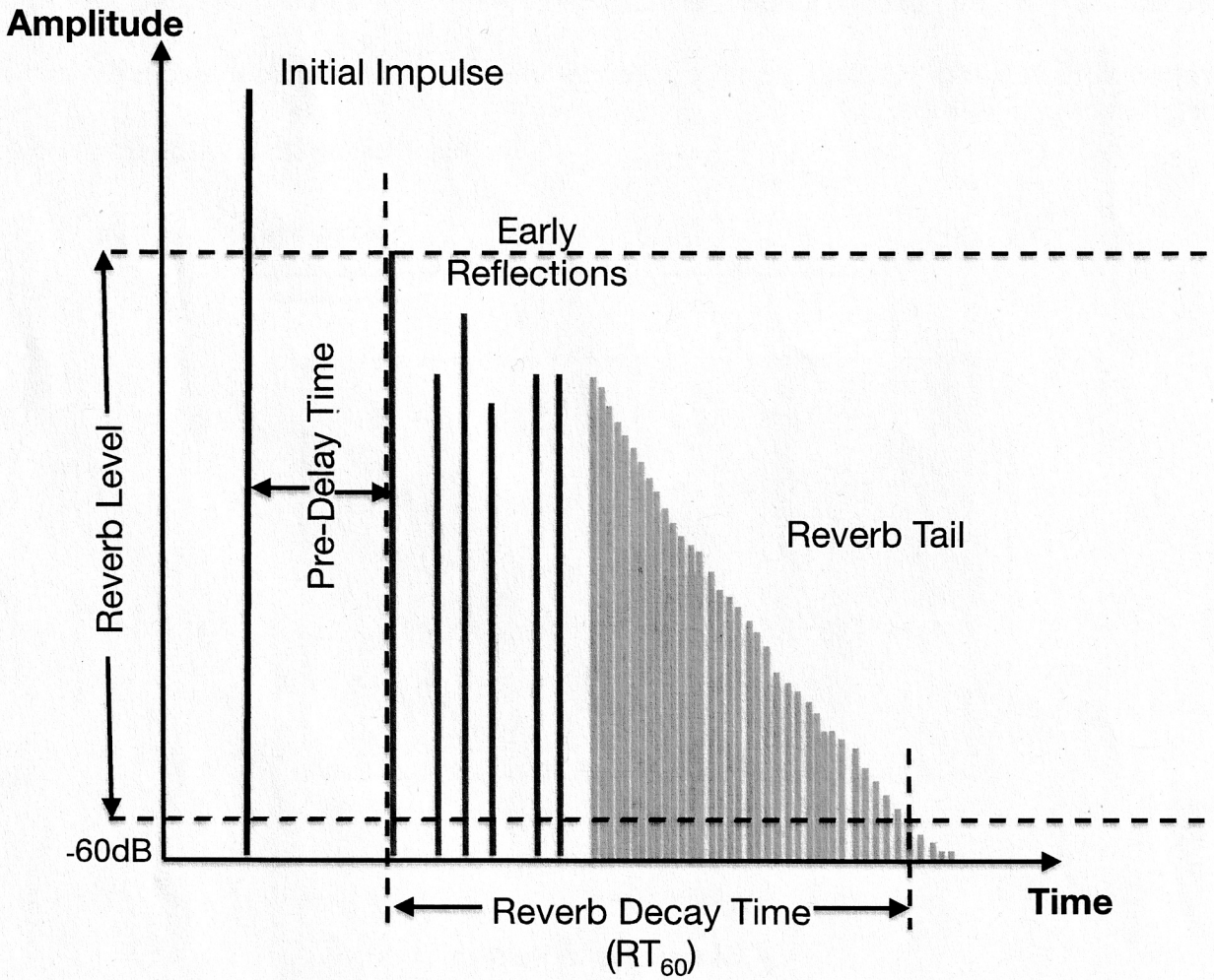
6 Reverb

Learning Objectives:

- Define **reverb and associated parameters** on the reverb **decay graph**
- Discuss **historical and current methods** of reverb production
- Consider how reverb can be used **creatively in a mix**

- Reverb is short for **reverberation**, and gives our brain information **about the space we are in**
- It results from **sound bouncing off surfaces around us**, and is like the echoes you hear when you make a sound in a place with **reflective surfaces**
- It is really useful in Music Technology because when we use **close mic recording techniques**, we aim to minimise the **natural reverb** we capture so we have control of the amount in the final mix.
- This means that we have to find ways of recreating it when we put a track together.
- An **anechoic chamber** is a space that is designed to have **no reverb.**

Graph of Reverb Decay



Echo Chambers

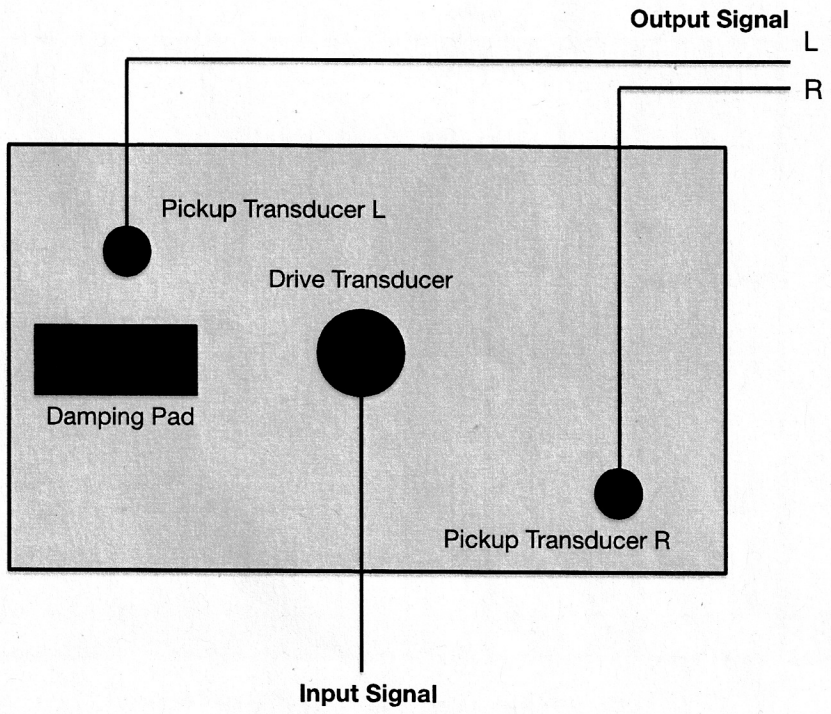
- Originally, reverb was created through a **variety of 'live rooms'** that had very different sounding reverb characteristics.
- This was **expensive**, and engineers soon found ways of **recreating these reverbs** in other forms in smaller rooms.
- One way was to find a **very reverberant room** and replay your mix on speakers in that room, using a pair **of omnidirectional microphones** to record the resulting echoes.
- Some studios used reverberant spaces they already had – for example the **office toilet**!

The Crystals – Da Doo Ron Ron
Tina Turner – River Deep Mountain High

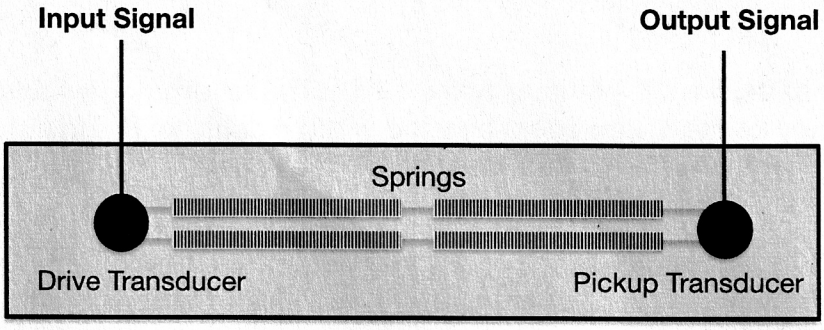
Plate Reverb and Spring Reverb

- Plate and spring reverb are both **methods of artificial reverb production** devised in the 1950s.
- Both used the **vibration of metal objects** to create the sound of reverb
- **Plate reverb** was often used in studios and avoided the need for an echo chamber.
- **Spring reverb** was often used in amplifiers; Fender was one of the first manufacturers to build spring reverb into their amps.

Beach Boys – God Only Knows



A Simple Plate Reverb



A Simple Spring Reverb

Digital Reverb

- Digital reverb was **first seen in effect units** made by Yamaha and Lexicon in the 1980s
- It models a reverb by **using lots of delays**, which are **mathematically calculated**
- Digital reverbs enabled users and manufacturers to **store lots of presets**
- As computer processors got faster in the 1990s, digital reverb was incorporated as a **software plugin**

En Vogue – Hold On

Convolution Reverb

- Convolution reverb **reproduces a real reverb from a real space**, and was pioneered by **Sony** in **1996**
- An **impulse reflex** is generated in a space, and the response is recorded
- **Mathematical algorithms** subtract the impulse reflex from the reverb and this can then be **applied to other sounds**
- Convolution reverb is very **heavy on processor usage**

Other Types of Reverb

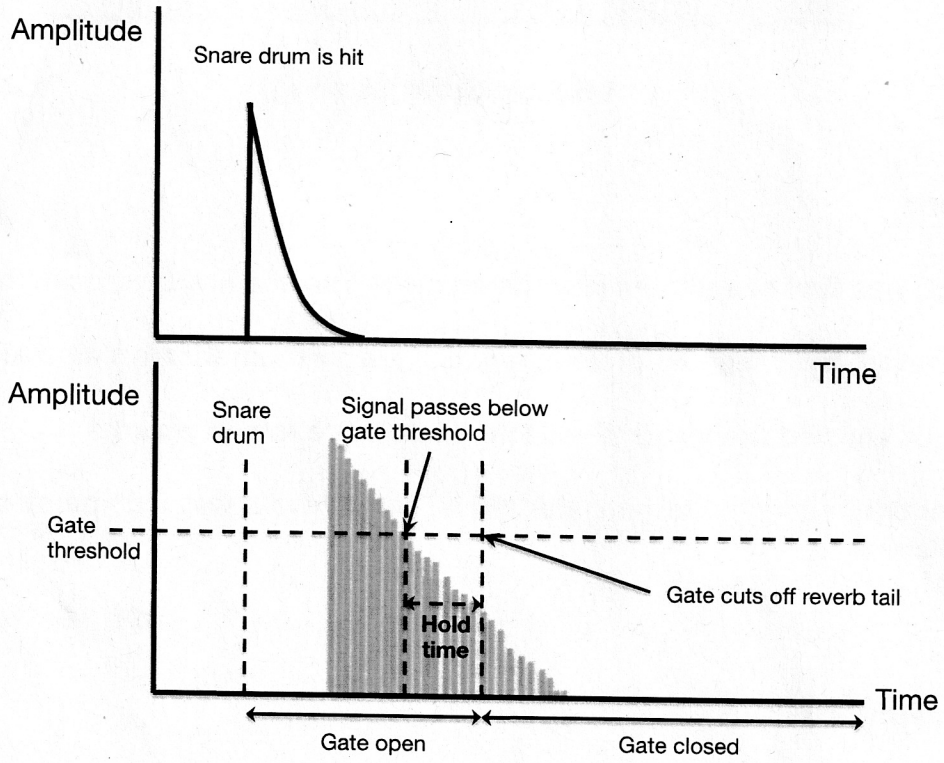
- **Reverse reverb** is created using a wet reverb signal played backwards. The original recording is then played forwards with the reverb which is first.

Beach Boys – Feel Flows
The Only Ones – Miles From Nowhere

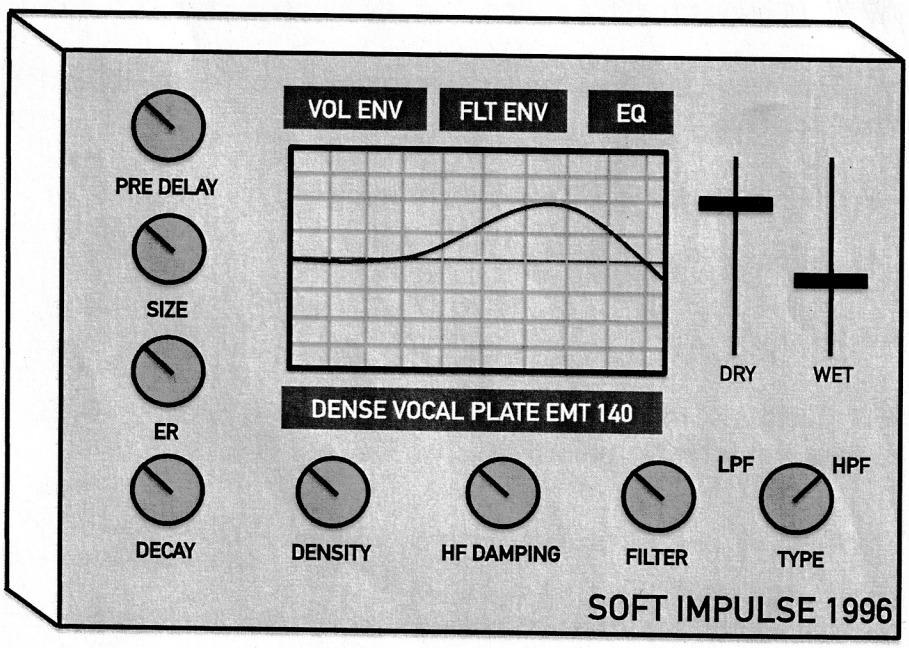
Gated Reverb

- In many styles of music, but particularly the 1980s, the **reverb decay was gated**, which meant that a very dense reverb could be used without causing 'muddiness' in the mix. **Gated reverb** is often used on snare drums and sometimes vocals.

Phil Collins – In The Air Tonight



The diagram below shows a simple convolution reverb. Label the parameters and their functions.



6 Reverb — Key Terms

Define the following key terms:

Terminology	Definition
Reverb	Short for reverberation and gives our brain information about the space we are in
Live Room	A room where you record with reverb in the room
Decay	Determines how long the sound will last before decaying
RT_{60}	The time it takes for the reverb of a sound to decay by 60dB.
Reflections	The sound waves that are reflected off surfaces in an acoustic space
Anechoic Chamber	A space designed to have no reverb
Echo Chamber	A special type of room to create an echo effect
Plate Reverb	often used in studios
Spring Reverb	often used in amplifiers
Digital Reverb	Uses lots of mathematically calculated delays
Convolution Reverb	reproduces a real reverb from a real space, created in 1994 mathematical algorithms calculate the reverb heavy on processor usage
Impulse Response	A digital recording of a sound's response in a given space or environment
Reverse Reverb	Created with a wet reverb signal played backwards
Gated Reverb	A type of reverb which suddenly cuts off after a certain time

7 Samplers

Learning Objectives:

- Define the **processes involved** in samplers and sampling
- Consider the **historical basis** for sampling
- Identify a number of **sample manipulation techniques**

- Sampling is when you take **a part of a song, single note or sound** and **reuse it in another context.** It is common to use a sampler to either record, manipulate or playback one of these pieces of audio material (or any combination of the three)

- Originally in the 1960s, samplers used **tape loops.** To change the pitch on a **tape-based recording**, the tape was played **faster or slower**. However, unfortunately, tapes were subject to **hiss, wow and flutter,** and **degradation.**

- The **mellotron** was a tape-based sampler with loops attached to each key used by The Beatles.

The Beatles – Strawberry Fields Forever
David Bowie – Space Oddity

- Sampling was later extensively **used in hip hop** (1970s and 1980s) using **turntables**

Sugar Hill Gang – Rapper's Delight
The Winstons – Amen Brother

- Drum machines **used early sampling technology** because the samples required were short and did not require pitch shifting.

- Modern day samplers are **digital,** and often triggered using MIDI

Working with Samples

- In modern day samplers, it is noticeable when a sound is **pitch shifted beyond a few tones** (when this is done in relation to a keyboard, we call it **'keyboard tracking').**

- **Multisampling** is used to overcome this, ensuring samples are only used over a limited range. **Velocity layering is** used to change the sample depending on how hard the key is played

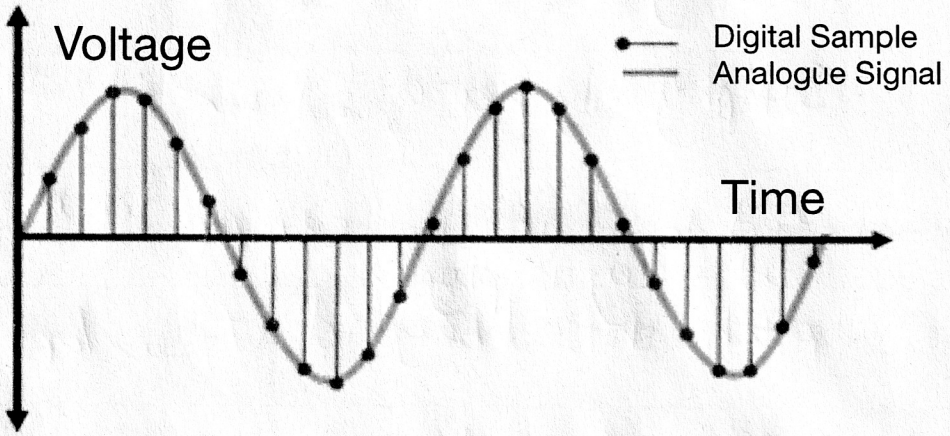
- It is important to ensure samples are edited at a **zero-crossing point** to avoid a click or a glitch; another solution is to use crossfade looping

Manipulating & Altering Samples

Loop	Repeats the sample
Normalise	Increases the volume to the maximum without distorting
Stuttering	Repeating small parts of the sample
Gapping	Adding spaces between small parts of the sample
Time Stretch	Extending or reducing the time of the sample independently from its pitch
Pitch Shift	Changing the pitch of a sample independently from its length
Reverse	Playing the audio data of sample backwards
Phase Invert	Flips the waveform so peaks become troughs and vice versa

Sample Rate and Bit Depth

- **Sample rate** and **bit depth** are measurements associated with digital audio and sampling
- The bit depth refers to the **number of possible amplitude measurements**
- The bit depth of the system below is **8 bit**
- The sample rate is the number of **amplitude measurements taken per second**



Digital Sampling

- When an analogue signal is sampled, we end up with a s**tream of numbers which make up the digital signal**
- This is usually measured in **binary code (0 and 1)**
- A common **bit depth** for high quality sampling and CD audio is 16 bit
- This means that there are $\mathbf{2^{16}}$ **possible amplitude measurements** (65536)
- A common **sample rate** for high quality sampling and CD audio is 44100Hz
- This caters to **Nyquist's Theorum,** which states that the sample rate is **twice the highest frequency captured.**
- Since the human hearing range is between **20Hz and 20000Hz, this** means that high quality sampled audio and CD audio is able to **capture all frequencies we can hear.**

7 Samplers — Key Terms

Define the following key terms:

Terminology	Definition
Mellotron	A tape based sampler with strips of tape attached to each key.
Destructive Editing	Editing that cannot be 'undone'
Multisampling	Sampling only being used over a limited range
Velocity Layering	Used to change the sample depending on how hard the key is played.
Keyboard Tracking	pitch shifted beyond a few tones.
Sample Rate	number of amplitude measurements taken per second
Bit Depth	number of possible amplitude measurements
Normalisation	Increases volume to max without distorting
Looping	Repeats the Sample.
Stuttering & Gapping	Stuttering is repeating small parts of the sample while gapping is adding spaces between small parts of the sample
Progressive Diminution	A technique used to alter the length of a sample by decreasing its size
Time Stretch / Pitch Shift → →	Extending or reducing the time of the sample Changing the pitch of a sample independently
Reversing	Playing the audio data of a sample backwards
Phase Inversion	Flipping the waveforms so peaks become troughs

8 Delay Effects

Learning Objectives:

- Identify how delay is **produced currently** and how this would have been achieved **historically**
- Discuss **delay parameters**
- Identify and discuss **specific delay effects** and **identify them in your listening**

- **Delay** is an effect that creates a repeat of a sound after it has been initially played.
- It can be used to create a **doubling echo** or an **automatic double tracking** effect.

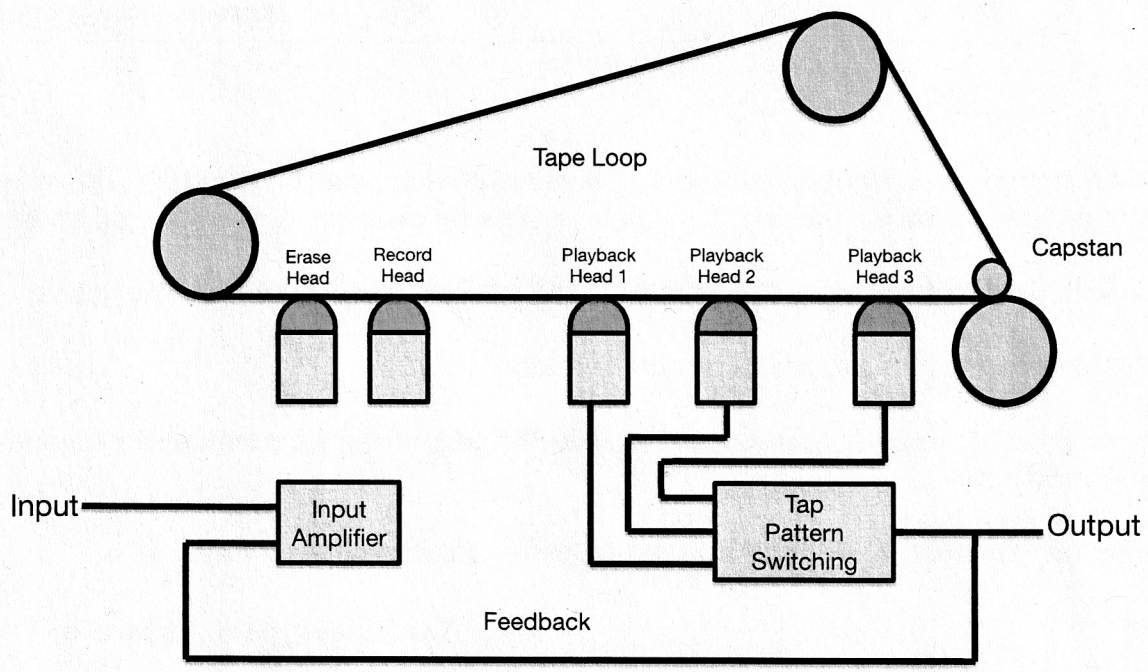
Delay Parameters

- **Delay time** is the amount of time between the initial sound and the repeat.
- **Feedback** is the amount of the signal that is fed back into the effect. This creates a trail of delays that gradually fades out.

Analogue Tape Delay

- **Analogue** tape delays were first used in the 1970s.
- **Multiple playback heads** gave **multiple repeats.**

Van Halen – Eruption



An Analogue Tape Delay Effect

Digital Delay Effects

- Modern digital delays are often incorporated as **guitar pedals** or **stompboxes.**
- They allow accurate control of **delay time** and f**eedback**, along with a variety of settings e.g. filtering. You can also use **multiple instances** of the delay plugin

Other Types of Delay

Slapback Delay	A single, quick (80-150ms) repeat of the sound at the same volume as the original signal. Often used in rock and roll on guitar and vocals. **The Kinks** – Waterloo Sunset
Timed Delay	Repeats of the original signal which are synchronised with the tempo of the music to give repeats which are 'in time' **Lady Gaga –** Just Dance
Stereo Delay	Repeats of the original signal which pan from left to right or move across the stereo field. Sometimes called 'ping pong' delay. **Martha and the Muffins –** Echo Beach
Sample Delay	A very short delay, measured in samples, allowing for phase correction or helping to create ADT effects.
Multitap Delay	A digital delay with multiple delay times and repeats, allowing complex rhythms to be built up. **U2 –** When The Streets Have No Name
Reverse Delay	The echo or delayed signal is recorded and played backwards; the original recording is then played as normal, but the delay now comes before it. **Led Zeppelin –** Whole Lotta Love

ADT

- When an instrument is **doubletracked,** it is **recorded twice**, singing or playing the same thing and **played back simultaneously**. It may sometimes be **panned** to give a stereo spread.
- **Automatic double tracking** was first used in the 1960s to reduce the time this takes
- It is sometimes known as **artificial double tracking**
- It clones, and then **slightly delays** and **detunes** the original signal, **panning** the original and copy left and right
- This gives **a 'thickening' effect** that is often applied to guitars and vocals

The Beatles – Here, There and Everywhere

Delay in other effects

- **Digital reverb** uses lots of different delays to mirror the reflections of a sound in a room
- **Delay** is commonly used to create **modulation effects** as part of creating the wet signal

8 Delay — Key Terms

Define the following key terms:

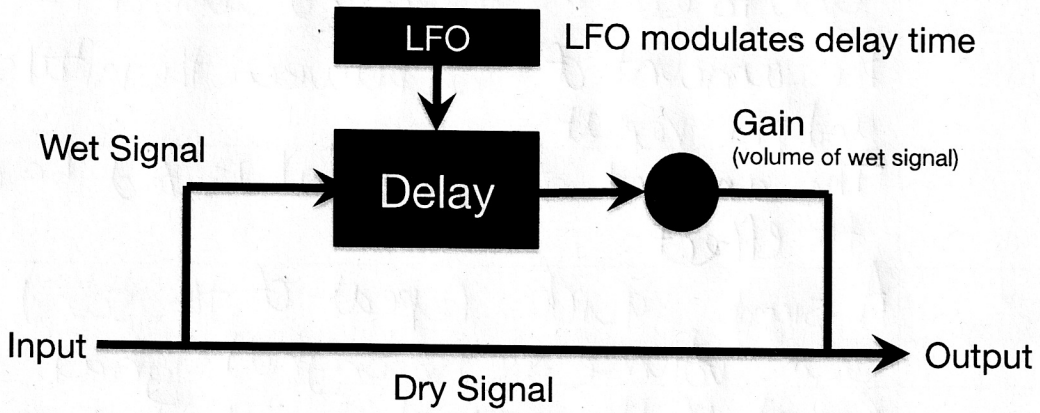
Terminology	Definition
Analogue	Uses electrical voltage to generate a signal
Digital	Uses computer technology to model other synthesizers oscillators
Tape Head	Records, reads or erases recordings and allows you to edit the speed and delay of the tape
Delay Time	the amount of time between the initial sound and the repeat.
Feedback	The amount of signal that is fed back into the effect.
Slapback Delay	A single quick repeat of the sound at the same volume as the original signal.
Timed Delay	Repeats of the original signal which are synchronized
Stereo Delay	Repeats the original signal which pan from left to right or move across the stereo field.
Sample Delay	A very short delay, measured in samples, allowing for phase correction when layering and all effects
Multitap Delay	A digital delay with multiple delay times and repeats, allowing rhythms to be built up.
Reverse Delay	The echo or delayed signal is recorded and played backwards: the original recording is played but the delay comes before it
Doubletracking	Recording a track twice and playing back simultaneously
ADT	Automatic double tracking clones, slightly delays and detunes the original signal, panning which creates a 'thickening' effect
Stompbox	A foot-controlled (relay) device

9 Modulation Effects

Learning Objectives:

- Discuss how **modulation is created** and **historical methods** of doing so
- Identify the **function of an LFO**
- Identify **specific modulation effects** and what they **do to the sound**
- Discuss the **effect of LFOs** on a wave

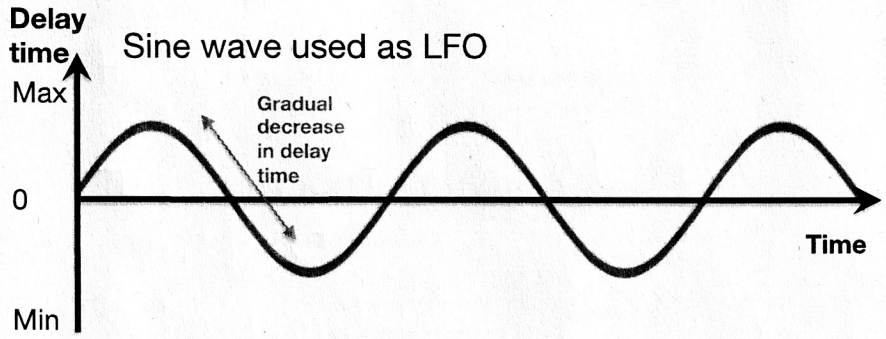
- **Modulation effects** involve making a parameter alter automatically over time
- **LFOs (low frequency oscillators)** are often used in order to do this
- Most modulation effects involve the combination of a **wet** and **dry** signal



Effect	Sound	How is it produced?	Examples
Chorus	'Shimmer'	Modulation of pitch and delay time to produce a layered effect ('chorus of voices'). Dry/wet.	Smiths – This Charming Man Nirvana – Come As You Are Crowded House – Don't Dream It's Over
Flanger	'Sweeping'	Modulation of delay time with feedback to produce a 'jet-plane' effect with movement. Dry/wet.	Heart – Barracuda Small Faces – Itchycoo Park Lenny Kravitz – Are You Gonna Go…
Phaser	'Movement / Plane'	Use of all pass filter to modulate the phase/delay depending on the frequency ('non-linear'). Dry/wet.	Sex Pistols – Anarchy in the UK Billy Joel – Just The Way You Are Radiohead – Paranoid Android
Vibrato	'Wobble of Pitch'	Modulation of pitch	Percy Sledge – When A Man
Tremolo	'Wobble of Volume'	Modulation of volume	Nancy Sinatra – Bang Bang REM – Crush with Eyeliner Radiohead - Bones

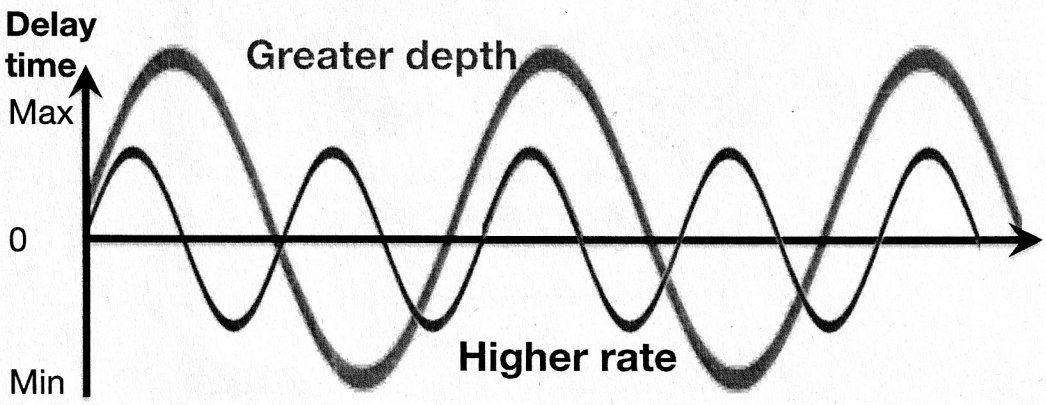
Using LFOs

- An LFO is a **low frequency oscillator**
- The frequencies used are **below 20Hz,** so they are inaudible
- An LFO changes a parameter of an effect or processor **according to another wave**
- Examples might be **altering the delay time according to a sine wave**. Other geometric waves can be used to change the effect of an LFO (e.g. square/triangle/pulse)



Controls on Modulation Effects

- Modulation effects have controls related to the **rate** and the **depth** of the modulation
- **Rate** is how fast the periodic change of the parameter takes place (wave **frequency**)
- **Depth** is how much the parameter is varied (wave **amplitude**)
- The combination of both of these parameters can change whether the effect sounds **subtle** or **very obvious**

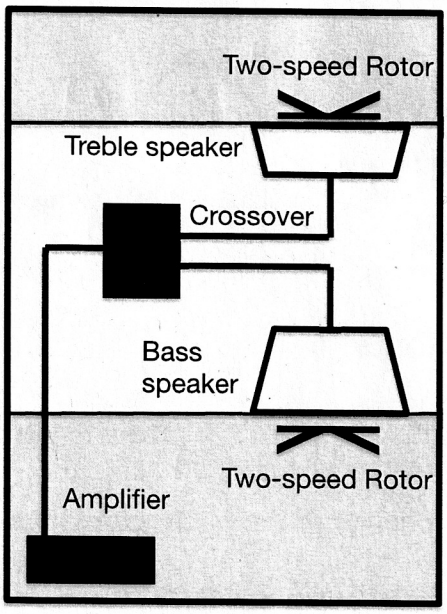


Historical Production of Modulation Effects

Leslie Speaker

- The Leslie speaker uses the **Doppler effect** to create modulation, and is sometimes called 'Rotary' on effect plugins.
- This is similar to the **changing pitch** heard when an ambulance passes you
- It is a system of **rotating speakers** used primarily with the Hammond Organ in the 1960s
- It occurs because the **source of a sound changes position, relative to the listener.**

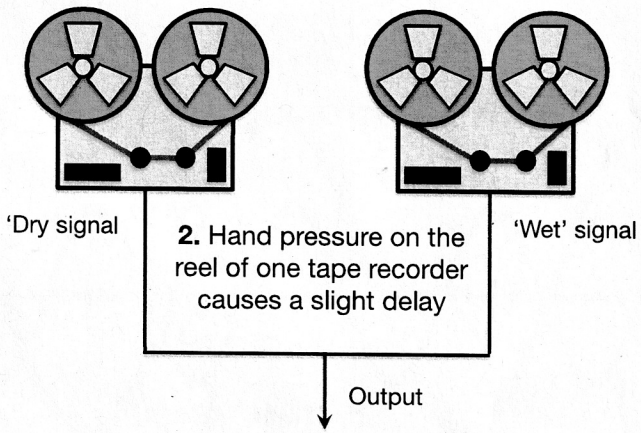
The Eagles – Hotel California
The Beatles – Let It Be



Tape

- Modulation effects were originally created by using **two tape recorders**

1. Same recording played on both tape machines



3. Combination of both signals gives an effect similar to a **flanger**

9 Modulation Effects — Key Terms

Define the following key terms:

Terminology	Definition
Modulation	Changing pitch, speed, volume, delay time
Chorus	Modulation of pitch and delay time with ~~feedback~~ delayered to produce a ~~'jet-plane'~~ effect ~~with movement~~.
Flanger	Modulation of delay time with feedback to produce a 'jet-plane' effect with movement
Phaser	Use of all pass filter to modulate the phase/delay depending on the frequency.
Vibrato	Modulation of pitch
Tremolo	Modulation of volume
Rate	How fast the perodic change of parameter takes place
Depth	how much the parameter is varied
LFO	low frequency oscillator, changes the parameter of an effect
Leslie Speaker	A system of rotating speakers which uses the doppler effect to create modulation
Crossover	where the sauce of a sound changes position as it sends high frequencies to treble and low to bass
All Pass Filter	Lets all frequencies through and doesn't filter these out
Wet Signal	Sound with effect
Dry Signal	Sound without effect

10 Distortion Effects

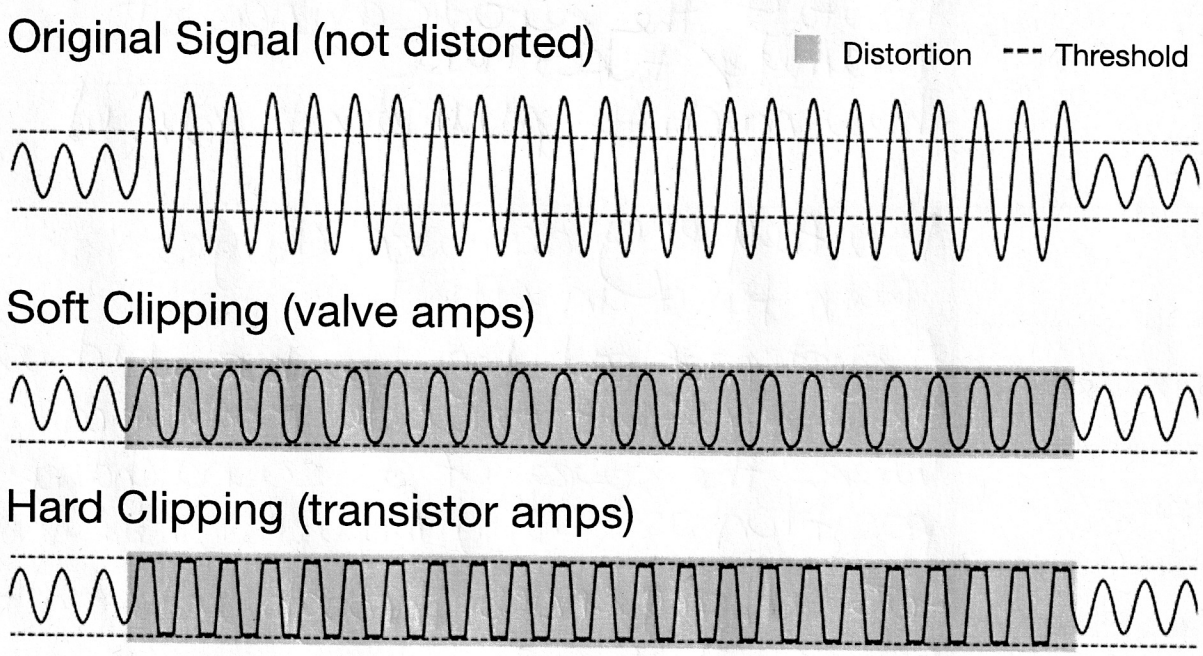
Learning Objectives:

- Identify **parameters on a distortion effect**
- Discuss **how distortion occurs**
- Give examples of the use of **fuzz and overdrive**
- Identify the difference between **soft and hard clipping**

- **Distortion** is created by turning the volume of a sound up too loud.
- It is primarily a **guitar effect**, created using a pedal or stompbox, or a DAW plugin
- We can control **three parameters** of a distortion effect:

Gain	The volume of the input signal (before distortion)
Output	The volume of the output signal (after distortion)
Tone	Changes the frequency content of the output

- Historically, artists created distortion by **damaging their amplifiers**
- When the **gain is increased**, the wave **peaks and troughs are clipped**



- **Soft clipping** rounds the tops of the waves and sounds warmer. It is often seen in **valve amps**. **Hard clipping** creates a wave with square peaks & troughs and sounds harsher; it is commonly seen in **transistor amps.**
- The distorted signal has **more harmonics**, and filtering / EQ may be required to **fit it well into the mix.**

Fuzz

- Fuzz is a **dense distortion** used by guitarists such as Jimi Hendrix

Jimi Hendrix – Purple Haze

Overdrive

- Overdrive gives the sound more **crunch.**
- It was originally created by **pushing amps to play louder** than they **were able to**

Chuck Berry – Johnny B. Goode

Ibanez Tube Screamer (TS9) Distortion Pedal

Bit Distortion

- Lowering the **bit depth** leads to **distortion of audio**
- The track can sound **'electronic'** or **'lo-fi'**

La Roux – Colourless Colour

Modelling Distortion

- We can use plugins to **model the sound of distortion**
- Software plugins include Logic's **'Overdrive'** and **'Bitcrusher'**
- We can also use hardware to emulate the sound of **different distortions and amplifiers**
- Line6's **Pod** emulates the sound of many different guitar rigs
- This is beneficial as it means that you can have the option of **lots of different amplifier settings** without **needing to own or transport** the physical amplifiers.

10 Distortion Effects — Key Terms

Define the following key terms:

Terminology	Definition
Pedal	A hardware device used to create varias effects on an electric guitar.
Gain	The volume of the input signal before distortion.
Tone	Changes the frequency content of the output
Output	The volume of the output signal (after distortion)
Clipping	when gain on a input signal is increased causing the wave peaks and trough to sound warmer or harsher
Hard Clipping	creates a wave with square peaks & troughs and sounds harsher; commonly seen in transistor Amps.
Soft Clipping	rounds the top of the waves and sounds warmer, usually seen in valve amps.
Valve Amp	An amplifier that uses vacuum tubes to increase the amplitude of a signal.
Transistor Amp	An amplifier that uses transistors to increase the amplitude of a signal.
Fuzz	A dense distortion
Overdrive	created by pushing amps to play louder than they usually should.
Harmonics	Mathematically and musically related waveforms.
Threshold	The volume above which compressor begins to compress the sound.

11 Creative Effects

Learning Objectives:

- Identify the **sound of creative effects** in popular music
- Discuss how **specific creative effects are created**

Talkbox	• Uses the mouth to **change / shape the frequency content** of sound • The musician uses a **tube** and changes the **shape of their mouth**; this is mirrored in the frequency change in the original audio **Bon Jovi –** Livin' on a Prayer
Vocoder	• Analyses the vocal signal and **applies it to a synth timbre** • Sounds **'robotic'** and the voice **follows the pitch** from the synth **Daft Punk** – Life Back To Music
Ring Modulation	• Dissonant effect that creates **metallic and ringing sounds** • It creates **frequency products** by adding and subtracting the input frequencies **Dr Who –** The Daleks
Pitch Correction	• Overuse of pitch correction or autotune (a **quick response time) forces the note to the nearest pitch** set by the user / scale • It is often **over-used in R&B** music to create a slightly robotic effect, or **subtly to keep vocalists in tune**. **Cher -** Believe
Stereo Effects	• Pan – comes from **'panorama'** in cinema • **Auto-pan** controls the place in the stereo field and is used to **introduce creative panning** throughout the stereo field • In tracks from the 60s and 70s, tracks were often **extreme panned** due to the **limitations of technology.** **David Bowie –** Space Oddity **Emeli Sande** – Next to Me
Pitch Shift / Harmonisers	• A pitch shift **alters frequencies** and **changes the musical note** that is played. **Harmonisers are intelligent pitch shifters** that can add a musical interval to a part (e.g. a 3rd above). • These effects would have been **created historically** by **slowing down or speeding up a tape.** **The Beatles** – When I'm Sixty Four **The Beatles** – In My Life **Lily Allen** – The Fear

11 Creative Effects — Key Terms

Define the following key terms:

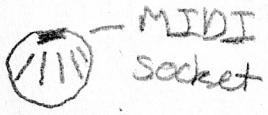
Terminology	Definition
Talkbox	Using the mouth to shape the frequency content of the sound
Vocoder	Analyses the vocal signal and applies it to a synth timbre.
Carrier	A signal that is used to modulate another signal used for vocoders.
Modulating Signal	~~changed pitch/sound, volume, decay time on a track~~ Dissonant effect that creates metallic and ringing sounds. used to modulate another signal
Ring Modulation	
Frequency Products	forces a note played in to the nearest pitch • The addition and subtraction of input frequencies
Pitch Correction	
Response Time	~~Takes~~ How fast the effect takes to cause the music to change.
Scale	The key in which a input is played in.
Pan	Comes from panorama in the cinemas where audio is moved to either left, right or centre.
Pitch Shift	alters frequencies and changes the musical note played
Harmoniser	Intelligent pitch shifters that can add a musical interval.
Cents	1/100th of a semitone.

12 MIDI

Learning Objectives:

- Define the **MIDI specification** and **GM**
- Discuss the difference between **switched and continuous** MIDI controllers, giving examples.
- Give examples of how MIDI can be used to create **musical expression**

- MIDI stands for **Musical Instrument Digital Interface.**
- It allows **different electronic musical instruments** and **equipment** to be **connected together**



MIDI Specification

- MIDI was introduced in **August 1983**
- It was a **joint standard** across different manufacturers
- It is a language; it **doesn't store audio data**. Rather it is a **set of commands** sent to connected instruments.
- Each instrument has its own **MIDI channel**. This means that it only responds to messages meant for it.

General MIDI

- General MIDI was a further set of requirements for MIDI devices that was intended to ensure **consistent playback between devices** (particularly with regard to instrument patches)
- GM requires **24-voice polyphony**, standardised **controllers & numbers** and **locations of instruments**
- Whilst MIDI files are very **small**, they are often criticised for sounding **unrealistic**; this is really a criticism of the equipment playing them back rather than the protocol itself.

Commands and Controllers

- MIDI controllers **change a characteristic** of the sound or track
- Controllers are either **switched** or **continuous**; switched controllers either have a value of **0 or 127**, so are **on or off**. Continuous controller values range between **0 and 127**.
- You can view controller data in the **MIDI event list** in your DAW, or sometimes in the **piano roll editor.**

Name	Number	Function	Switched/Continuous
Modulation	1	Adds vibrato (modulates pitch)	Continuous
Volume	7	Changes overall track volume	Continuous
Pan	10	Moves between L, C and R	Continuous
Expression	11	Volume fine-tuning	Continuous
Sustain	64	Holds on notes	Switched
Portamento	65	Bends between notes (glide)	Switched
Reverb Depth	91	Adds reverb (amount)	Continuous
Chorus Depth	93	Adds chorus (amount)	Continuous
Reset All	121	Stops all controllers	Switched

MIDI Controllers and Numbers

Quantise

- Quantise is used to move notes that are poorly timed back onto the beat where they are meant to be. It achieves this through 'snapping' each note to a grid, the size of which is determined by the **note resolution** you choose
- Resolutions are defined by the number of the the notes you could fit in a bar of 4/4 (e.g. 1/1 – 1 semibreve; 1/2 – two minims etc...)
- It has been criticised for removing the musical expression from the music. Thus, some more **advanced quantise functions** were created:
    - Swung quantise
    - Groove templates
    - Iterative quantise
    - Humanise

Articulation and Velocity

- Articulation is how the notes are played; short or long, slurred together or detached.
- This is recreated by altering parameters of the MIDI note, in particular the length and velocity
- You could change the synth's **envelope** to mirror the specific articulation of an instrument
- In Logic, 'Gate Time' can be used to change the feel of the MIDI data
- When a **note on** command is sent to a MIDI device, it is sent with a specific velocity value (from 0 to 127). This relates to how hard the note is struck
- Velocity is a useful method of us **recreating the sound of real instruments** and avoiding MIDI sequences **becoming mechanical.**
- Synthesisers commonly assign **filter envelopes that are dependent on velocity**

12 MIDI — Key Terms

Define the following key terms:

Terminology	Definition
MIDI	~~A MIDI device which is used to control the~~ The acronym for Musicial Instrument Digital Interface.
Channel	A specific channel within the midi protocol, used to send and reciere messages.
Polyphony	Ability of a MIDI device to play multiple notes simultaneously.
Controller	device used to control the parameters of a MIDI sound
Switched	A type of controller that sends a signal when its state is switched to another.
Continuous	A type of controller with a range of possible values between 0 to 127.
Modulation	Adds vibrato to a sound.
Expression	Volume fine tuning.
Portamento	Smooth movement from one pitch to the other.
Glide Time	The time taken for a movement to occur.
Quantise	used to adjust the timing of MIDI notes.
Velocity	Speed at which a MIDI note is played.
Envelope	The set of controls to change Attack, Delay, Sustain and Release.